THE

VALUE OF PHYSICAL SCIENCE

IN THE

WORK OF EDUCATION.

AN ADDRESS DELIVERED JULY 25TH, 1865, UPON LAYING THE CORNER-STONE OF THE JENKS CHEMICAL HALL

AT LAFAYETTE COLLEGE.

BY

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EXTRACT FROM THE MINUTES OF THE BOARD OF TRUSTEES.

LAFAYETTE COLLEGE, July 26, 1865.

Resolved, That the thanks of this Board be presented to BARTON H. JENKS, Esq., of Bridesburg, for his generous offer to erect a suitable building for the use of the Chemical Department of this College.

Resolved, That President CATTELL, Professors TRAILL GREEN, and J. H. COFFIN, Mr. JAMES MCKEEN, and M. HALE JONES, Esq., be a Committee to superintend the erection of the building after the design furnished by John McArthur, Jr., of Philadelphia, and that said building be known as the JENKS CHEMICAL HALL.

Resolved, That the thanks of the Board be presented to the Rev. Professor W. HENRY GREEN, D. D., for his address of yesterday, delivered by request of the Faculty, at the laying of the corner-stone of the new Hall, and that a copy be requested for publication.

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ADDRESS.

We are met to lay the corner-stone of The Jenks Chemical Hall. Connecting this event with its probable consequences, we may pronounce it one of real magnitude. Every right impulse given to the cause of education is of incalculable value. Every addition to the means, every increase of the facilities of manly culture deserves to be hailed with gratitude and joy. He who extends the advantages of intellectual and moral training to those who would not otherwise have possessed them, or renders more complete and thorough the discipline of mind and heart of those who are in a course of instruction, ought to be held in honour as a public benefactor. And when this is done by a permanent foundation, whether by the erection of neat and appropriate buildings, such as that which is here contemplated for scientific uses, or by endowments securing in perpetuity a succession of able and qualified teachers in sufficient numbers, or affording to deserving but needy pupils the requisite pecuniary assistance, we see one of the noblest uses to which

money can be put, and we admire their largeness of heart and breadth of view and far-sighted benevolence, to whom God has given along with wealth this comprehension of its real value, and the wisdom to convert it into exhaustless mines of treasure, which cannot be weighed with gold.

The great problem in our collegiate system is to combine in the most effective manner the wide diffusion of liberal culture with the highest possible attainments. As institutions of learning are multiplied, the advantages which they offer are put within reach of greater numbers, and many are induced to avail themselves of privileges cheaply offered and brought to their doors, who would have been deterred by distance and expense. Each creates about itself a fresh circle of literary influence, and inspires a zeal for learning in some at least who would never have felt the stimulus of remoter institutions even though they were of a higher order.

There is a danger, however, of dissipating our forces, and wasting our strength by scattering upon too many points what could only be really effective by being concentrated upon a smaller number. No small injury has resulted to American scholarship by the solicitude to increase the number, irrespective of the character of our colleges. If they be feebly manned and poorly equipped, they are an evil and an incumbrance, stand-

ing in the way of others and a check upon their prosperity, while doing a real injury to as many as resort to them, who are cheated out of the education which they might have obtained elsewhere.

A college to fulfil its true idea, and to answer in any worthy manner the end of its establishment, ought to be possessed of ample facilities for the work of a thorough education. It should be possessed of an adequate corps of instructors well versed in their various departments, of abundant apparatus of the best description, of large and well selected libraries, of scientifically arranged cabinets and museums. It ought to be in an eminent sense a seat of learning, a centre of instruction not only to the immediate body of pupils gathered there, but from which knowledge should radiate to the wider public. The professors should be provided with all the appliances necessary for prosecuting learned investigations and engaging in the work of scitific research and discovery, so that they might be advancing the boundaries of knowledge and making additions of permanent value to the general stock of our literature. All this cannot be without large endowments. The outlay involved is necessarily very great, though the returns will be such as abundantly to compensate for it.

Every true friend of LAFAYETTE is rejoiced to see her bestirring herself with such zeal and such a hopeful

measure of success in this direction. The leading institutions of the country have been moved as by one common impulse to seek the enlargement of their endowments, and thus increase their facilities for imparting a broad and thorough culture. And the noble and generous response made to these solicitations will always remain an honourable record. That during a civil war of such magnitude, entailing such sufferings and losses, and demanding such enormous expenditures in its prosecution, the American public not only bore uncomplainingly the burdens thus necessarily imposed upon them, but continued still to sustain with even more than their former vigour their accustomed charities and operations of religious benevolence, and added to these those extraordinary contributions poured forth without stint in aid of the Christian and Sanitary Commissions and kindred agencies, and beyond all, contributed princely sums, greater than at any former period, for the permanent endowment of literary and theological institutions; this may well stand to the credit of our people and repel the charge so often made of sordidness and supreme devotion to mere material wealth.

We accept it as a pledge and augury for the future, that in this new stage of its history upon which our country is now entering, a higher style of education will be sought after and insisted upon, than has thus far been attained to. In the preliminary work of

opening up this vast continent, such has been the demand for labour in every department, that men grudged the time required for a thorough training. The necessity was so urgent, that poorly furnished workmen were better than none. We are now passing into a more settled state of things, for which the convulsions of the last four years seem designed to prepare the way. It was a question whether such an extent of territory could be held together, and whether, as our population expanded, it would not fall asunder of its own weight; whether the divergent tendencies of individual freedom and of distinct local governments would not prove too strong for the central authority; whether our very prosperity was not depraving our national character, and engendering a weakness which was the precursor of dissolution; and whether the system of slavery, which had been first tolerated and then petted, though diametrically opposed to the principles of our government, was not gaining such control over our national councils as to make this free nation the propagandist of bondage.

These questions were to be met and settled before we could be suffered to grow into a populous nation. The providence of God has brought them, as we hope and trust, to a final solution. A sentiment of nationality has been developed, crushing every tendency to secession and disintegration, and inspiring the whole

people with the instinct of a common life. The heresy of unlimited State sovereignty has been effectually rebuked, and the true doctrine of our national Constitution has been vindicated by the strong arm of the people. A spirit of heroic self-sacrifice and devotion to the public good has been awakened in the heart of the nation, which will not lightly part with that for which it has toiled and suffered, as it did from the assault upon Sumter to the surrender of Lee. And slavery has ceased to be.

These perils are now past. Our institutions have been tested and purged. They are actually stronger than they were, and our confidence in them has been increased. They have borne the sudden and enormous strain to which they have been subjected, and have demonstrated their capability to bear the pressure to which expanding numbers and advancing time will be sure to subject them. It is the experimental test prior to actual use. We are now, under the leadings of God's good providence, to unfold ourselves to a mighty people, and to develope the civilization for which he has destined this continent, with its marvellous structure, its amazing resources, and its wonderful history.

To guide in this developement, and to make it what it should be, the highest powers of mind and heart will be required. We need in our statesmen and legislators, we need in our ambassadors at foreign courts, we

need in every profession and line of life, what we have learned at a terrible cost was needed in our generals. A thorough course of training appropriate to their work is necessary to fit them for it. Third and fourth-rate men will answer the necessities of the country no longer. We want well-developed, full-grown men, whose powers have been cultivated to the highest attainable point—the ablest and best who can be produced—who have had every advantage for self-culture afforded them, and have made good use of their advantages. The fostering care bestowed in this great crisis upon our educational institutions is full of hope, as it shows that the quick sense of our countrymen has discerned the urgent want of the times, and is bent upon having it supplied.

The Hall, whose corner-stone we are about to lay, suggests by contrast the straitened accommodations for the chemical class in the model school basement, and the slender apparatus of my college days. The only matter of astonishment, is that so much was accomplished in the way of experiment and illustration by the ingenuity and skill of our respected instructor, the same who still adorns this department, and the only link remaining to connect the faculty as it is now and as it then was. It is a matter of sincere congratulation, in which I am sure all his former pupils and all the friends of the College will join, that his past ser-

vices and his eminent abilities have met the recognition to which they are entitled; and that instead of struggling in the future, as he has done in the past, against untold disadvantages in his work of instruction, he is henceforth to be provided with the needed appliances, and to have a laboratory and apparatus worthy of the College, befitting the present advanced state of chemical science, and which will compare favourably with those of the best institutions of the country. But one thing more is needed to put this department on the best possible footing, and to make it all that any friend of education can desire—a step the natural sequel of that which has been taken this day, and which, I trust, a generous and appreciative public will not suffer to be long delayed, viz., that this professorship should be fully endowed, and my respected friend and teacher, whose admirable fitness for the post is confessed by all who know him, should be relieved from the exacting demands of his medical practice, and enabled to devote his undivided strength to the proper duties of his professorship.

And I cannot forbear in passing to congratulate the College upon the whole series of buildings—finished, begun, and projected, which are to adorn this hill; and particularly upon that whose corner-stone we saw laid last year, and which, besides its general and obvious connection with my theme, has an intimacy of relation

with it, which they who are acquainted with the munificent donor, will appreciate. It, too, by contrast, suggests memories of the past, of the honoured and lamented MACARTNEY, whose panegyric I would love to pronounce, if this were the proper place and time. I recall, as though it were yesterday, the gathering of my class about him on the College campus one starlight night, as he pointed out the leading constellations, traced the path of the sun in its annual course through the heavens, and indicated the principal lines upon the celestial globe,—the observations taken from the College cupola on the day of the annular eclipse,* and the sundry uses of quadrants, theodolites, &c., for obtaining the elements wherewith to compute latitude, longitude, and various celestial phenomena. I cannot but think what effective use he would have made for purposes of instruction, and for purposes of science, of this observatory, with its equatorial, its transit, and other instruments; and I rejoice at the facilities put into the hands of his accomplished successor, and which will doubtless increase a scientific fame already widely spread.

The present advance of education is taking more and more the direction of natural science, not with the view of superseding the existing curriculum, but of supplementing it. We see this in the various scientific

* September 18th, 1838.

schools and agricultural schools, and schools for the arts and for mining, which are founded as separate institutions, or erected in connection with our best endowed colleges. We see it in State endowments for these purposes. We see it in the growing public demand for that particular style of instruction, which must be met in some form or other. We see it in acts of munificence, like that which has prompted the founding of this astronomical observatory, and this chemical hall.

The reasons which have contributed to and which justify this movement, are manifold.

One of the most important is derived from the part, which it is coming to be more and more distinctly seen, the natural sciences are capable of taking in the training of the mind, in that which is the grand aim of a liberal education, the development of the man.

The materials for the mental training of each generation are to be found in the intellectual achievements of its predecessors. Another can teach us only by leading us to think the thoughts which he has had, and to rise to the conceptions which he has gained. It is by exercising them in the realms of truth, under the guidance of those who have already explored them, that our powers grow. It is by toiling through the passes over which former travellers have made their way, and clambering up the steps which they have hewn in the

precipitous rock, that we acquire strength of muscle and firmness of tread. The most effective discipline for strengthening and expanding the mind is setting it to grapple with the problems that the great master spirits of our race have struggled with and laboured at, and shown us how to solve.

There is a deep philosophy in the common word *information.* It implies that the impartation of knowledge *informs* the mind, gives shape and form and character to what would otherwise be confused, chaotic and unmeaning. The intellect untaught is like shapeless, unwrought material, "rudis indigestaque moles." Knowledge exerts a moulding influence upon it, brings its hidden faculties into conscious exercise, developes its latent capabilities, gives bent and direction to its powers, acts the part of the sculptor who discovers shapes of beauty in the marble which only had an ideal existence there before.

The best system of education that can be devised in any age or country, will depend upon the sum of knowledge which is possessed and can be made available for the training of the mind. Mathematics owes its name to the fact that in the early period of Greek culture it constituted the course of study—*μαθηματικά*, "the things to be learned." It was the only well developed body of knowledge then existing that deserved the name of a science. And the clearness and

precision of its ideas, the rigour of its methods, and the evidence and certainty of its results, made it a favourite discipline with reasoners. It has retained its place in the curriculum of liberal study ever since. But meantime how has it been expanded by the modern analysis and the calculus, by new applications to mechanics and optics, to the laws of fluids and the motions of the stars, to every branch of physical science and of human art? And who would now dream of limiting a course of mathematical study to the geometry which Plato made preliminary to an entrance upon philosophy?

The well-known trivium and quadrivium which composed the curriculum of the middle ages, embraced the principal branches of science cultivated then.

The revival of classical learning introduced the study of the polished languages of Greece and Rome among the regular branches of education, at first chiefly for the sake of an introduction to that elegant and varied literature to which they afford the key, afterwards in addition for the discipline of mind which the mastery of the tongues themselves imparted. But how much does the study of language now involve beyond what was thought of or imagined at the beginning! The entire science of philology, with its revelations of the inner structure, the growth and the affinities of tongues is of recent growth.

Physical science has very commonly been under-

valued as a means of education. It is said, and very properly, that the principal aim of the college course is not the communication of knowledge, but the discipline of the mind. Still, if the views presented are correct, these are not independent of one another. It is by the reception of knowledge that the mind is stimulated to activity and its powers put to their proper use, so that they can receive their just expansion and developement. Mere collections of facts, however carefully observed and exactly recorded, would, it is true, be of small account in the training of the mind. A meteorological register would be of no avail for purposes of education. Facts unconnected and unexplained are mere lumber in the memory of the student. They do not educate. They require no thought, no processes of comparison, judgment, or reasoning. They suggest no clear ideas. They do not constitute science. Science implies classification and arrangement: phenomena must be traced to their causes, principles be connected with their consequences, and the ideas which govern the whole be clearly set forth.

The vulgar eye looks at the flame of a candle and sees nothing but a very ordinary affair, which scarce attracts attention. Science detects in that hollow pyramid of incandescent carbon, which we call flame, a world of wonders. The laws of decomposition and recombination are therein illustrated; the equilibrium

of forces acting in various directions to which the blaze owes its steadiness and regular shape, its apparent continuity, though made up of minute and separate particles, and its seeming permanence though renewed like the rainbow at every successive instant; the tremendous energy of these forces, which is such that the molecules of oxygen eliminated from the surrounding air, impinging from infinitesimal distances upon molecules of solid carbon disengaged from the gas which held them in combination, produces an intensity of heat greater than ponderous trip-hammers urged by the most powerful machinery can produce by repeated strokes on bars of metal, and suggesting among its endless analogies and relations that sublime cosmical hypothesis which finds an adequate cause for the permanent and undiminished heat of the sun in a like play of forces and the impinging of nebulous matter upon its surface; and beyond all the mysterious nature and wide connections of light and heat are opened for consideration. So that it is not surprising that one of the most distinguished chemists of the present day made the flame of a candle his text in a most instructive series of lectures, such as it would be in a high degree educating to listen to and to follow.

That amber when rubbed draws light substances to itself, and that the loadstone attracts iron, were phenomena known to the ancients. But they had no

notion of the causes that produced them, or of their multitudinous relations. They never thought of any laws involved, or principles that had a wider range of application. And yet when curiosity had been stimulated to careful investigation and these vague hints were followed out to their results, it was found that these seemingly isolated phenomena were after all not freaks of nature, but starting points of an extensive system. The discovery that in each case the attraction was matched by a counter-repulsion, gave birth to the idea of polarity with all its wonderful applications. The agents in these phenomena were further recognized on a large scale in the sphere of the world; the one in the lightning flash and various electrical manifestations, the other in the magnetic condition of our globe. The properties of these two analogous and yet dissimilar fluids, if so they are to be called, open a broad range for separate investigation. A third discovery, which ran its independent course for awhile, served however ultimately to combine them at the same time that it threw the tract of investigation still more widely open. The galvanic fluid possessing remarkable properties of its own and yet capable of producing all electrical phenomena on the one hand, and magnetic on the other, compels to the conclusion that what were once reckoned three distinct fluids, are in reality modifications of but one agent. And the wonderful affinities and con-

nections which this has with light and heat, raise the query whether they too are not ultimately traceable to the same common source. And further still in this process of extension and simplification, this same agent has been recognized as the bond of chemical affinity. The power, which holds the elements of compound bodies in combination, can be thrown into the form of a current of electricity and conducted along the voltaic wire: this power can be accurately measured and subjected to rigorous computation, and thus Faraday demonstrated that the gaseous elements of a single grain of water are held together by an electrical force equivalent to 800,000 discharges of his Leyden battery, or a powerful flash of lightning. And this again explains the secret of the definite proportions in which alone chemical composition takes place; the combining equivalent of each simple element, denoting the constant proportion in which it enters into its various combinations, being precisely represented by its fixed electrical quality.

It is needless to multiply these illustrations. The simplest matters of observation involve principles or are traceable to causes which have endless ramifications. The study of physical science which redeems individual facts from their isolation, substitutes clear and precise conceptions for vague and indefinite notions, which refers phenomena to their laws and effects to their causes, brings into operation the faculties of the mind

and gives them that training and developement which is the object of every wise scheme of education.

The educative power of the physical sciences appears further from the amount of vigorous thought which has been expended in their formation, the impress of which they consequently bear in their own structure, and leave more or less distinctly upon all the minds that are brought into contact with them. Men of the highest acuteness and ingenuity have patiently exercised themselves through successive ages in solving the problems which nature spreads before them. It is upon the products of their toil our minds employ themselves, and by the treasure they have amassed, we are enriched. In the beautiful language of Professor Whewell—"The present generation inherits and uses the scientific wealth of all the past. * * * When the humblest inquirer counts his little wealth, he finds that he has in his hands coins which bear the image and superscription of ancient and modern intellectual dynasties; and that in virtue of this possession, acquisitions are in his power, solid knowledge within his reach, which none could ever have attained to, if it were not that the gold of truth, once dug out of the mine, circulates more and more widely among mankind."*

Even the elemental ideas of science, the foundation on which all rests, and without which no structure could

* Philosophy of the Inductive Sciences, vol. i. p. 271.

be reared,—ideas which once gained and clearly stated carry their own evidence with them, and are accepted as axioms, were nevertheless elaborated by the struggles of ages, and men worked their way up to them by a slow and tedious process. To the uninstructed, nature is a vast enigma, containing only the most obscure and distant hints of its own true solution. Patient and protracted search, involving many fruitless endeavours and many perplexed and devious wanderings, was the condition precedent to the discovery of the truth. Why does a stone continue to move after it has left the hand by which it is thrown? And why is its motion gradually retarded until it ceases altogether? These were questions that all antiquity could not answer. The great Aristotle had nothing better to suggest than that there was a motion communicated to the air, the successive parts of which urge the stone onwards. The cessation of the motion was universally attributed to the sluggishness of the material, and its inherent disposition to return to a state of rest. The conception had never dawned upon their minds, which we now hold to be axiomatic, that matter has no tendency to change its state whether of motion or of rest. But until this conception had been distinctly apprehended, it was impossible to make the slightest progress towards constructing a science of mechanics or determining the laws of force and motion. And then only was the way

open to determine the true character of the solar system and of the stellar universe. Without this primary principle there is no escape from the old idea that the stars are animated beings, moving in circles, as the most perfect of figures, and the earth is immovable in the centre.

The word chemistry, which comes to us from the ancient Greeks, and was perhaps borrowed by them from the Egyptians, testifies that researches in this direction began at a very early period. But how completely the ancients were groping in the dark in regard even to the first principles of the subject, appears from their doctrine of the four elements, earth, air, fire, and water. The notion fundamental to the whole subject of the elementary constituents of bodies to be determined by actual analysis, was never once dreamed of. From the Greeks the study passed to the Arabs, of whose labours we have a reminiscence in the technical terms *alembic*, *alkali*, *alcohol*. But how far they still were from distinct and true conceptions even in fundamental points, appears from the name of the science in its Arabic form, *alchemy*, which is most prominently associated with the vain endeavour to transmute the baser metals into gold. This delusion is inconsistent with the first notion of the essence of bodies, which can never lose its identity amid all mutations and combinations.

The sciences are thus built up by slow degrees; in

every part they bear the evidence of severe thought. They are the results of clear and powerful thinking persistently directed to the solution of intricate and difficult problems. From their simplest truths to their loftiest and most far-reaching deductions they bear the stamp of master intellects whom it is in the highest degree educating to follow.

But the educating power of physical science is capable of being put on higher ground than this. Though its texture is human, the material is divine. Man is the interpreter but the handwriting is God's. The office of science is not to impose human ideas upon nature, but to uncover those of the great Creator. In studying the world which he has given us to exercise our minds upon, we are pupils of the Almighty and the All-wise. We are searching into his plans. We are learning to think his thoughts and take in his ideas. Every arrangement down to the most minute, every method adopted, every end sought, wears the stamp of divinity. And then there is no school for grand and lofty conceptions, for ideas fitted to enlarge the mind, exalt its powers and kindle its enthusiasm like this in which our Maker is our teacher. What could give a practical impression of the vastness of immensity and boundless space like the lessons of astronomy,—or of the unnumbered ages of a past duration like the revelations of geology,—or how purely relative are the terms

great and small, like the teeming millions of microscopic life converting a tiny drop into a world of animated being.

And what can surpass in grandeur those bold yet simple inductions of the invariable permanence of matter and of force. No natural agency, no created being can alter the amount of matter in the universe to the extent of an atom, or change the sum of force to the extent of the feeblest impulse. They can add nothing to it; they can take nothing from it. They may burn, pulverize, scatter to the winds, strew upon the sea, convert into invisible vapor, but they cannot annihilate a particle, or destroy one of its essential properties. Every atom of oxygen that the world contained at its formation, is in it now, and will so continue to the end of time, with all its properties precisely as they were at the beginning. It may have been breathed in air, and drunk in water, and eaten in food, it may have waved in the forest and roamed in the animal, it may have been hewn out in the rock and smelted in the ore,—it may have entered successively into thousands upon thousands of combinations:—and yet through all these shifting forms, and after all these various uses, it remains unwasted, undiminished, and unaltered, without the slightest modification in any of its properties,—the same unvarying atom, changeless in the midst of limitless, incessant change.

What a commentary on the language of inspiration, "I know that whatsoever God doeth it shall be forever; nothing can be put to it, nor anything taken from it." Eccl. iii. 14.

But I proceed to remark that physical studies are well adapted to cultivate qualities or habits of mind essential to a well-balanced character, or to a properly educated man. It teaches humility, that prime quality in a philosopher and indispensable element of true greatness, by showing the narrow limits within which our knowledge is confined, and the ages required to evolve truths which now appear self-evident. It teaches patience with difficulties, unbiassed love of truth for its own sake, habits of intelligent observation, the ability to extract gratification and profit from whatever is around us; and in the combination of men of various nations and of different creeds in the pursuit of a common end it gives promise of universal union and fellowship, a dim foreshadowing of that glorious future which God has promised in his word.

I cannot, however, dwell upon these and other points, which naturally suggest themselves in this connection; and shall barely pause a moment upon a single feature of character of great consequence which the discipline of these studies is calculated to cultivate in a high degree. I mean caution in drawing conclusions, not resting satisfied with deductions from partially apprehended

facts, nor generalizing too hastily from narrow premises, nor accepting that which at first sight appears plausible until it has been subjected to the most rigorous tests. This caution is characteristic of true science. It is always wary of being misled by false appearances, and mistaking the seeming for the real. Nothing is accepted which does not rest on a solid basis of fact, and the most cherished opinion is discarded or freely modified when it can be shown not to be coincident with well established truth. The whole range of physical inquiry is fruitful of illustrations. The history of every science is but the gradual correction of what was at first incorrectly conceived or inadequately apprehended, the elimination of errors and inaccuracies by rigidly subjecting every proposition to the test of experiment and observation. The captivating phlogiston hypothesis gave way before the increased accuracy of the chemist's balance, which established the fact that in spite of appearances and of popular belief weight was, in all cases, increased not diminished by combustion, and therefore the process is one of addition not of subtraction. Oxygen is added; not phlogiston set free.

Lavoisier ascertained that oxygen entered into the constitution of a great number of acids, and hence concluded that every acid contained oxygen; but the discovery of chlorine and hydrochloric acid showed that a limitation was necessary, which science did not fail to

make. When Dalton propounded his atomic theory he supposed that he had settled the fact of the existence of ultimate atoms and of their relative magnitudes; but further research has shown that combination in definite proportions was dependent not on the size or weight of irreducible molecules but of the electrical quality of simple bodies. There seemed to be much to favour the hypothesis of one electrical fluid, positive and negative, rather than of two, vitreous and resinous; but it is fatal to the former that it required the assumption of a mutual repulsion between the particles of matter after the electricity has been withdrawn; for bodies negatively electrified repel each other as well as those which are positively electrified. So the hypothesis that light and heat are imponderable substances long struggled for the mastery with the hypothesis of undulations; but the latter has at length possession of the stubbornly contested field. Chemists are now puzzling themselves over the mysteries of isomeric and allotropic substances—compounds of precisely the same constituents or simple substances clearly identical and mutually convertible, and yet possessing widely different properties, as oxygen and ozone, or the two forms of phosphorus. Confronted by such facts as these, what does science do? Hastily conclude that substances have no fixed properties, or manfully confess ignorance and patiently wait for a solution, assured meanwhile that a solution is pos-

sible, and that seeming inconsistencies between clearly established truths will some day be cleared up?

And when difficulties or apparent inconsistencies are alleged between physical science and revealed truth, what can the true philosopher do but that which physical science is perpetually doing in its own domain? Where the difficulty arises from a misconception or mistaken theory on one side or on the other, let the requisite correction be applied and harmony restored. Where the difficulty after every attempt at explanation remains insoluble, patiently wait for further light. Truth cannot but be self-consistent. Abandon neither the evidence of your senses on the one hand, nor the assurance of a well-established faith on the other, but calmly abide in the confident anticipation that in this, as in hundreds of instances before, an increase of knowledge will reveal the mutual consistency of the word and works of God.

I have already taxed your patience unduly, and can only hint at what I had purposed further to say.

Physical science has a claim to be included in any complete course of education, on account of its striking analogies with moral and religious truth. These belong to different spheres, but they were wrought by the same Divine hand and upon a similar model. Ideas gained in the one tend to enlarge and clear our apprehensions of the other. The language, which we constantly employ respecting the higher forms of truth, is largely

based on imagery drawn from the lower. Light is the natural emblem of truth and holiness and joy; and the knowledge of the physical properties of the former opens a fresh insight into the moral relations of the latter. The grand simplicity of the law of attraction which pervades the universe, controlling equally what is vast and what minute, the near and the remote, constraining all to orderly and harmonious movement, exalts our conception of the sublime control of God's great law of love, by which the universe of moral being is controlled and harmonized, and made to circle around himself. In "the permanent and stable course of nature, resulting from the balance and neutralization of contrary tendencies,"—centripetal struggling with centrifugal forces,—winds battling with waves, heat with cold, acid with alkali, pole set over against pole, free play allowed to mutually conflicting affinities, and opposing properties, yet all so adjusted as to form a perfect equilibrium which the roll of ages cannot disturb, there is presented an impressive counterpart to God's providential agency, in which all things work together for good, in which evil agencies and sinful passions and wicked men are made to thwart and check each other, and to promote instead of disturbing the wise and holy and beneficent purposes of the great Creator.

And what enlargement and expansion is given

to scriptural figures drawn from natural objects by gaining a fuller knowledge of those objects themselves. "The Lord God is a sun," conveys a striking and impressive truth, when we think of the sun only in his obvious character as a source of light and heat. But what new energy is given to this magnificent emblem when we learn from astronomy that he is a grand centre of attraction, and when we in addition take in that sublime generalization that the sun is the ultimate source of every form of power existing in the world. The wind wafts the commerce of every nation over the mighty deep, but the heat of the sun has rarified the air and set that wind in motion. The descending stream yields a power which grinds your grain, turns your spindles, works your looms, drives your forges; but it is because the sun gathered up the vapour from the ocean, which fell upon the hills, and is finding its way back to the source whence it came. The expansive energy of steam propels your engines, but the force with which it operates is locked up in the coal, the remains of extinct forests, stored among your hills, or is derived from the wood that abounds in your forests, which now crown and beautify their summits. Both these primeval and these existing forests drew their subsistence from the sun; it is the chemical force resident in his rays, which disengaged their carbon from the atmosphere, and laid it up as a source of

power for future use. The animal exerts a force by muscular contraction; he draws it from the vegetable on which he feeds; the vegetable derives it from the sun, whose rays determine its growth. Every time you lift your arm, every time you take a step, you are drawing on the power the sun has given you. When you step into the railway carriage, it is sun-power that hurries you along. When gentle breezes fan your languid cheek, and when the resistless tornado levels cities in its fury, they are the servants of the sun. What an emblem of Him, in whom we live and move and have our being!

Physical science has a further claim to take part in the education of our youth, because of the direct testimony which the world renders to its glorious author. The whole subject of final causes, and the argument from design, which offers itself at every step to the student of nature, here lie open before us.

The relations of science and revealed religion are manifold, and the points of connection are continually becoming more numerous and important. It is of the utmost moment to the intelligent Christian, and to every thoughtful man, especially to them that are to be leaders and guides of public opinion, not to say professional defenders of our holy faith, to be well informed upon the whole subject, to be put in possession of the most recent phases of opinion, and the latest results of

scientific inquiry. It is only thus that they can have a correct appreciation of the exact state of questions that are in debate. It is only thus that the friends of the Bible can be saved on the one hand from the heedless folly of abandoning or overlooking their own strong points of defence, criminally spiking their guns and betraying them into the enemy's hands; or preserved on the other hand from resting the cause of religion on weak and insufficient arguments, linking it with false and exploded theories, and rendering not only themselves but the truth of God ridiculous by the ignorance and unskilfulness of their advocacy of it.

I can only allude to what is the most weighty consideration yet adduced, but one which it would require a volume properly to unfold.

I have not referred in my argument to the practical bearings of physical science, to the valuable uses to which this knowledge may be put in agriculture, in the mechanical arts, in manufactures, in mining, in the various trades and professions. These are obvious, and are the considerations which are commonly pressed. It is important that our schemes of education should not be disjoined too much from practical utility under the idea of caring exclusively for the training of the mind, the developement of the man. We want men trained in such a way as to fit them for ready usefulness in the active, busy world. And on the other hand we wish that

those who merely aim at what they think a direct preparation for the activities of life, should receive in connection with it a liberal education, a developement of the whole man. Hence I rejoice in the association of a scientific course with the college as a part of the curriculum to be pursued there. And I have aimed to show that it will not degrade the college curriculum, but tend to render it more complete and effective, to give to the physical sciences an enlarged share in the work of education, a share better proportioned to their magnitude and importance.

I thank you, ladies and gentlemen, for your patient attention; and join you in wishing that JENKS CHEMICAL HALL, whose corner-stone we shall now proceed to lay, may long continue to adorn this hill, to contribute to the usefulness and prosperity of LAFAYETTE COLLEGE, and to perpetuate the name of its generous founder.